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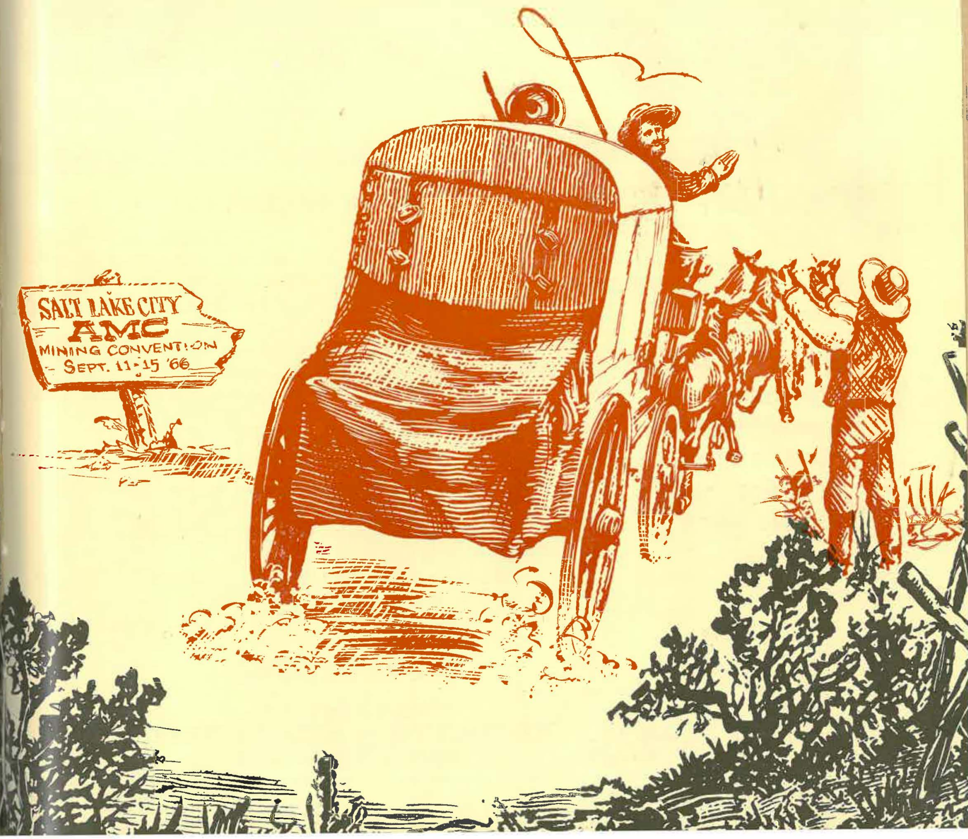

MINING CONGRESS JOURNAL

AUGUST 1966 VOL. 25 NO. 8

ARTICLES

Opinions expressed by the authors within these pages are their own and do not necessarily represent those of the American Mining Congress.

55 Air Pollution and the Coal Industry

James R. Garvey

Growing demands for cleaner air have serious implications for the coal industry since more than half of the coal used today goes for generation of electricity and the coal-burning electric utilities are most likely to be affected by any air pollution restrictions. Garvey reviews the pollutants in coal and discusses ordinances that have been passed to restrict use of fuels containing in excess of one percent sulfur.

DISCUSSION: James R. Jones

There is a sense of urgency in the matter of air pollution control, and it is important to the coal industry that any controls established can be complied with technologically. Answers must be found to many unsolved problems, and while much progress is being made to find solutions, are the city councils, health officials, citizens' committees, etc., convinced and willing to wait?

68 Reliability Engineering and Its Application in Mining

Jay C. Dotson

Reliability engineering is widely used in the aerospace industry to assure mission successes, and the concept of reliability analysis is gaining ground in the automotive industry and with commercial airlines. It has potential uses in the mining industry anywhere that uninterrupted operation of facilities is essential to maintaining uniform production.

84 Should You Build One Very Large Plant or Two Medium Size Plants?

Edward T. McNally, Robert C. Woodhead, and John L. Gamble

The question posed by the title of this article is answered by comparing hypothetical flow sheets for an 800 tph preparation plant with several combinations of two 400 tph plants. The main conclusion reached is that the controlling factor appears to be the cost of operating two medium size plants against the cost of operating one. Finally, any decision for preparation plant construction will be related to special locational and operational considerations.

Departments

Special Sections

On Our Cover

Westward Ho! has been the American slogan of mobility from stagecoach days down to the modern era of automatic transmission and the superhighway. The mining industry turns its headlights toward the Great Open Spaces in September when it gathers in Salt Lake City for the American Mining Congress Metal Mining and Industrial Minerals Convention. For an advance look at this major event on the year's mining calendar see pages 37 to 48.

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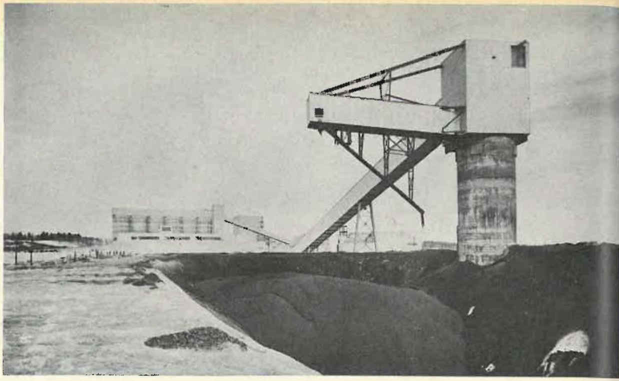


Minus ¼ in. chips screened from the pellets are stored in an 800-ton silo for separate loading of this product. Pellets are delivered to the open stockpile by a fixed, cantilevered belt conveyor

clamshell type, and are operated by hydraulic cylinders controlled by solenoid valves actuated from the control console. The hydraulic lines are electric traced to maintain the oil at a satisfactory viscosity at sub-zero temperatures in the winter months.

The weighing function is by means of a hopper-type beam scale, which is fitted with an electronic load cell in the tension member immediately before the weigh beam. On automatic operation the signal from the load cell is electronically compared with a preset signal representing the desired weight, and the bin feed gate position is governed by the difference between these signals. When they are in agreement the feed gates close. On manual operation the gates are closed by the operator using the indicating weight meters on the control console and the counter in the printout equipment cabinet as guides. A high speed data printer is paralleled with the counter for paper tape printout.

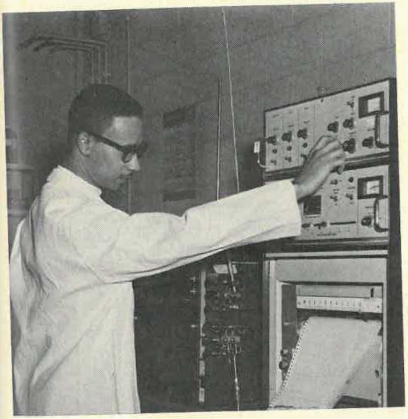
The stockpile and load-out installation described has been in operation since the end of 1964. To date it has handled in excess of 1¼ million tons of pellets, equivalent to about 18,000 railroad cars. It has met expectations as a fast and efficient weighing and locating system for unit train movement of pellets.

Air Pollution and the Coal Industry

By JAMES R. GARVEY
President
Bituminous Coal Research, Inc.

SO much emphasis has been placed recently on the problem of water pollution that one might conclude that air pollution is of somewhat lesser importance. However, with the growing demand by health officials for cleaner air, it may not be necessary for many coal producers to be concerned about water pollution—the loss of markets resulting from air pollution restrictions will eliminate the need for coal production and all its attendant problems.

Although all coal markets are likely to be affected by air pollution restrictions, the one of most concern is coal's current largest market, namely, the use of coal for generation of electricity. This market, comprising over 50 percent of present production, is one for which many economists have predicted phenomenal growth in the future. While this discussion is concerned with control of air pollution as it relates to the use of coal in the electric generating plants, the effects of more stringent pollution restrictions on other markets cannot be ignored either.



Bench-scale studies are part of a major coal industry research program to develop more effective means for control of air pollution in existing and future coal-fired installations. Shown here is a technician operating gas chromatograph used in these studies at Bituminous Coal Research, Inc.

Some Combustion Products Totally Innocuous

When coal is burned at a power plant to produce steam which, in turn, is used in the generation of electricity, a number of combustion products are formed which must be disposed of. Some of these, such as nitrogen, oxygen, and water vapor, are completely innocuous and not considered to be pollutants. Others, both gases and solids, are suspect, and, according to public health officials, result in billions of dollars' worth of property damage each year in addition to adversely affecting the health of the public.

The particulate matter in the effluent gases consists of mostly an inert material, the ash contained in the original coal. In most power plants, especially the modern, efficient type, the amount of this material emitted is less than one-half of one percent of that contained in the original fuel. Such plants are equipped with extremely efficient dust collectors which remove the particulates from the dust stream.

In addition to the inert fly ash, some coal-burning plants may also produce and discharge a submicron-sized particulate which is primarily an unburned hydrocarbon, usually benzo-a-pyrene. This compound has been demonstrated to have carcinogenic characteristics; it is the same material contained in tobacco smoke and in the exhaust gases from gasoline and diesel burning engines. Sampling programs on coal-burning plants have demonstrated that in the modern, efficient power plant either none or an extremely small amount of such material is produced.

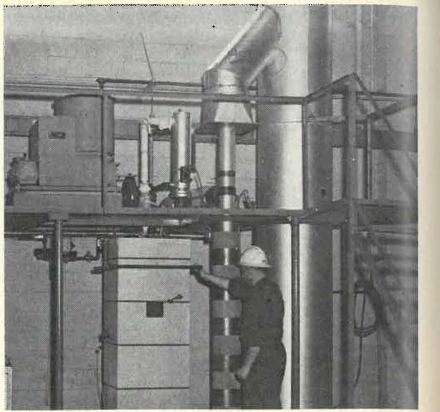
Emission of CO_2 Under Serious Study

Among the gaseous materials discharged from the stack is carbon dioxide. This is not generally considered to be a pollutant inasmuch as it has never been demonstrated to have any adverse effects on plants or animals. However, to illustrate the far-reaching aspects of the air pollution problem, it should be noted that serious studies are underway to determine whether more restrictions should be placed on the emission of carbon dioxide to the atmosphere. There is evidence that the amount of carbon dioxide in the earth's atmosphere is increasing rapidly as a result of the combustion of fossil fuels. If the future rate of increase continues as it is at the present, it has been predicted that, because the CO_2 envelope reduces radiation, the temperature of the earth's atmosphere will increase and that vast changes in the climates of the earth will result. Such changes in temperature will cause melting of the polar icecaps, which, in turn, would result in the inundation of many coastal cities, including New York and London.

The oxides of nitrogen, notably nitrous oxide and nitrogen dioxide, which are produced as a result of the high temperatures of fossil-fuel combustion, are receiving considerable attention by air pollution officials, although at the present time no restrictions have been imposed. The oxides of nitrogen and the subsequent photochemical reactions which take place in the atmosphere have been demonstrated to be a principal cause of the smogs which afflict such cities as Los Angeles.

Oxides of Sulfur Main Public Concern

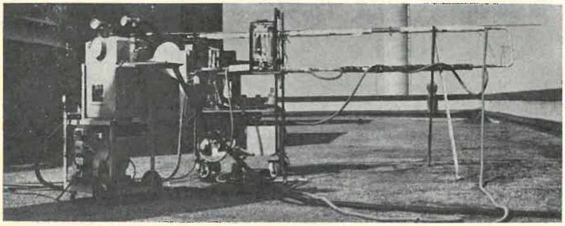
And finally, we have the oxides of sulfur, sulfur dioxide and sulfur trioxide. These oxides are of most concern at the present time, because public health officials have convinced themselves of their deleterious effects on plants, animals, and humans. As a result, such cities as New York are passing ordinances, either restricting the sulfur content of the fuel or the amount of sulfur dioxide which may be emitted from the stack in such a manner that a coal of less than one percent sulfur content will be required to comply, or expensive control equipment will have to be added to the power plant.



Operation of a five lb per hour pulverized coal-fired furnace is studied at Bituminous Coal Research in conjunction with bench-scale research on air pollution control

Is this stringent control of sulfur oxide emissions necessary? This is not known, and to date there seems to be no substantiating evidence that minor amounts of sulfur oxides in the air are in any way harmful. This evidence is lacking despite the fact that for over 40 years research on the effects of oxides in dilute quantities has been conducted by renowned scientists, both medical and otherwise, throughout the world. As recently as November 7, 1965, the Environmental Pollution Panel of the President's Science Advisory Committee said in its report:

"While we all fear, and many believe, that long continued exposure to low levels of pollution is having



Studies are being conducted on atmospheric contaminants in flue gases in a two-year research project sponsored by the U.S. Public Health Service. Shown here is stack sampling equipment installed at a power generating plant

James R. Garvey joined Bituminous Coal Research, Inc. in 1946 as a development engineer. Since then he has served successively as supervising engineer, assistant director of research, director of research and, since 1963, as president. As president of BCR, he is responsible for development and execution of the cooperative research program of the coal and related industries. In addition, Garvey is vice president, research and engineering, of the National Coal Association, a BCR affiliate. In that capacity, he manages the industry's cooperative engineering service program as well as its research.

unfavorable effects on human health, it is heartening to know that careful studies have so far failed to to produce evidence that this is so. . . ."

And Dr. William T. Ingram, consultant to the New York City Health Department, and a professor at the New York University and Cornell Medical Center, stated recently that current information on sulfur dioxide does not warrant the sulfur controls proposed by the New York City Council's Special Committee on Air Pollution.

Dilute Concentrations May Not Harm

There is little written evidence that sulfur dioxide in dilute concentrations is harmful; on the contrary, there is some evidence that a little sulfur dioxide is helpful in preventing the common cold, and that dilute amounts also offset the damaging effects of other pollutants on plant life.

The foregoing refers to dilute concentrations of sulfur oxides, and so it would be well at this point to define what concentrations are involved in order to put the whole picture in better perspective.

In the conventional, modern, coal-burning power plant, coal of, for example, 3.4 sulfur content is drawn from a storage bunker through a mill where it is pulverized to about talcum-powder size, blown into a combustion chamber where it is ignited and the heat used to produce steam. The resultant gases and particulates pass through a heat exchanger for extraction of additional heat from the hot gases, thence to a high efficiency dust collector where 99-plus percent of the particulates are removed. In these particulates are included about ten percent of the original sulfur which was in the coal, so that the gases discharged to the stack contain about 3000 parts per million (ppm) by volume SO_2 and about 30 ppm SO_3. The gases are discharged 400 to 800 ft above ground level, and because of the buoyancy of the gas they rise rapidly, mix with the surrounding air, and by the time they eventually settle to the ground, the dilution is such that the concentration will be of the order of less than 0.3 ppm. Thus, after starting with a three-plus percent sulfur coal, a 0.3 ppm concentration of SO_2 at ground level is obtained. As a general rule, the ground-level concentration will be related to the sulfur content of the fuel in about this ratio of one to ten. Thus, three percent sulfur coal produces 0.3 ppm SO_2; one percent sulfur coal will produce about 0.1 ppm SO_2 concentration.

A concentration of 0.1 ppm at ground level has been suggested by the Public Health Service as the maximum level which is desirable despite the lack of evidence that such an extremely low level is necessary or even desirable. Contrast this concentration with the concentration approved by industrial hygienists for persons working around smelters and other such plants where high concentrations of sulfur dioxide are produced. The threshold limit for such workers is set at five ppm over an eight-hour working period.

Unrealistic Ordinances Are Being Resisted

What effect would such limitations on sulfur contents (either a 0.1 ppm ground-level concentration, or the roughly equivalent one percent sulfur in the coal) mean insofar as coal's leading market, the utility plants, is concerned? A recent study of the sulfur content of coals used by such plants is shown in figure 1, which demonstrates that about 90 percent of these plants use coals having sulfur contents greater than one percent.

Fig. 1. Sulfur Content of Utility Coals

% Sulfur	% of Total	Cumulative %
0.4–0.7	4.9	4.9
0.4–1.0	10.4	10.4
1.1–1.6	12.8	23.2
1.7–2.2	20.4	43.6
2.3–2.8	14.6	57.2
+2.8	42.8	100.0

And while the problem is significantly serious throughout the entire United States, it is even more significant in certain localized areas. For example, in the Midwest where 35 percent of the utility market exists, the average sulfur content is 3.2 percent, and even at the 1.5 percent sulfur limitation, only 8.7 percent of the coals used would qualify.

Every possible effort is being made by the various coal associations and by many of the coal companies themselves to resist the imposition of unrealistically restrictive ordinances on the sulfur content of fuels. At the same time, the reality must be faced that there will be a gradual tightening of the allowable limits, hopefully not down to the one percent, which appears to be totally unrealistic, but certainly below the average now being shipped to power plants. What can be done to enable producers of high sulfur coals to comply with these limitations and thereby protect their current utility markets and obtain the potential of growth which exists?

Pyritic Sulfur Can Be Removed from Coal

Sulfur occurs in coal in two primary forms, organic and pyritic. The question is often asked, why cannot sulfur be taken out of the coal before it is shipped to the power plant? Sulfur content of bituminous coals varies from 0.5 percent to over six percent. The organic content varies between 20 and 60 percent of

Fig. 2. Studies of Eastern Coals

Size	Pyrite	Sulfur Analyses Organic	Total
Raw	2.40	1.70	4.10
		Cleaned at 1.6 Sp. Gr.	
2 × 0	1.42	1.70	3.12
¼ × 0	1.27	1.70	2.97
60 M × 0	0.82	1.70	2.52
		Cleaned at 1.3 Sp. Gr.	
60 M × 0	0.26	1.74	2.00

Fig. 3. Studies of Mid-Western Coals

Size	Pyrite	Sulfur Analyses Organic	Total
Raw	3.11	2.25	5.36
		Cleaned at 1.6 Sp. Gr.	
2 × 0	1.59	2.25	3.84
¼ × 0	1.59	2.25	3.84
60 M × 0	0.81	2.25	3.11
		Cleaned at 1.3 Sp. Gr.	
60 M × 0	0.18	2.63	2.81

the total sulfur in the coal. This organic sulfur is a part of the coal molecule itself and cannot be separated from the coal except by disintegration of the molecule; therefore, its removal prior to combustion is impossible.

The pyritic portion of the total sulfur content of bituminous coals occurs as pyrite, a mineral associated with the coal but not chemically bound to it. Because there is no chemical bond, it is theoretically possible to separate the pyritic forms of sulfur from the coal. However, in many, if not in most bituminous coals, this pyritic sulfur occurs as a finely disseminated particulate substance; and in order to release it, it is necessary to crush the coal to an extremely fine size. The need for this crushing and the limitations on cleaning at a preparation plant are illustrated in figures 2 and 3. Figure 2 shows the results of studies made on a typical Eastern coal supplied in large quantities to utility plants. The raw coal, as mined, contains 4.10 percent total sulfur, of which about 58 percent is in the pyritic form. Cleaning of the raw, 2 × 0 coal at 1.6 specific gravity will reduce the pyritic sulfur content from 2.40 to 1.42 percent, the organic sulfur will remain unchanged, and the total sulfur will be reduced from 4.10 to 3.12 percent. Cleaning such as this is, as coal producers well know, a common practice at many preparation plants. As was pointed out earlier, pyrite for the most part is contained in coal as a finely disseminated material, and in order to effect appreciable removal of the pyrite it is necessary to crush to an extremely fine size. By crushing the coal to ¼ × 0 some additional pyrite is freed, and washing will change the total sulfur content, reducing it to 2.97. Crushing to 60 × 0 mesh enables reduction of the pyritic sulfur content to a little over half of what was contained in the original coal, but coal of this size cannot be shipped by conventional means to existing power plants and the problems of handling and storing it at the power plant would be insurmountable.

Overcleaning May Increase Organic Sulfur Content

Some studies were also conducted at 1.3 specific gravity. Although a substantial further reduction on the 60 mesh × 0 size can be achieved, only 58 percent of the coal is recovered, and the organic sulfur content of the coal is actually increased. The reason for this is when coal is cleaned at a low gravity, the low organic sulfur materials are concentrated in the refuse and the high organic sulfur constituents are concentrated in the clean coal. This anomaly of actually increasing the organic sulfur content by overcleaning is apparent in all coals tested, although to a greater degree in some than in others.

Midwestern coals have also been studied, and the results are shown in figure 3. Again, when cleaning at 1.6 specific gravity, the 2 × 0 size can be reduced in pyritic sulfur from 3.11 percent to 1.59. The crushing of the coal to ¼ × 0 does not free enough additional pyrite to enable further reduction in the pyritic sulfur content of the clean coal. But when the coal is crushed to 60 mesh × 0, the reduction is significant and a coal containing about one-quarter of the original pyrite can be produced. However, inasmuch as this coal contains a high proportion of organic sulfur, the total sulfur content still exceeds 3.11 even when cleaned at 60 mesh. Cleaning at 1.3 specific gravity enables additional removal of the pyrite, but the clean coal recovery is of the order of 35 percent. The organic content of this clean coal, for reasons previously explained, shows a marked increase so that the overall reduction in total sulfur between cleaning at 1.6 specific gravity and 1.3 specific gravity is not significant.

Gas Processing Could Be Alternate Approach

The alternative approach to control of sulfur dioxide emission from fossil-fuel-burning plants is to the application of a process for recovering the sulfur dioxide from the flue gases after burning but prior to emission from the stack. Such gas processing can have efficiencies from a three percent sulfur coal from 3000 ppm at stack top to the order of 300 ppm. A corresponding reduction in ground-level concentrations would, of course, result, and if such processing means could be applied, the emissions would be well below any levels now being considered by public health authorities.

No simple process exists, although several research developments within the past few years show promise. The difficulty of developing a technically feasible and economically practical process can readily be appreciated when one realizes that for every ton of coal burned in a utility-type plant, 400,000 cu ft of gases are discharged to the stack. Even with a high sulfur coal the amount of sulfur dioxide in these gases is less than 0.5 percent. The plant to process this volume of gas to remove such a minute trace of sulfur dioxide will be large and costly to install and operate.

Substantial research progress has been made in the direction of development of practical and economic processes for recovering SO_2 from flue gases. The research has passed the laboratory stage, but in order to provide solutions to the problems remaining and to develop such processes to the point where the overall economics are feasible, additional research is necessary, especially in the pilot and prototype plant stages.

Three Processes Look Attractive

The U.S. Bureau of Mines, utilizing available laboratory information, has developed some probable cost figures for three promising processes. These include the Reinluft Process developed in Germany, the Alkalized Alumina Process developed by the Bureau, and the Catalytic Gas-phase Process which has been worked on by Bituminous Coal Research, Inc. and a group of manufacturers headed by Pennsylvania Electric Co. Figure 4 shows a summary of the cost data developed by the Bureau.

These three processes are the most attractive of many which have been studied over the past 10 to 15 years, both in the United States and abroad. Their attractiveness is enhanced by virtue of the fact that all produce a potentially salable by-product, either sulfur or sulfuric acid.

Examination of figure 4 indicates the great effect which the type of plant has on process costs. A significant difference appears between a plant operating with a 90 percent operating factor, versus one with a 50 percent operating factor. The fact that costs range from $0.75 per ton of coal to $2.65 illustrates that for the small plant such processes at the current state of development are not yet feasible.

The significance of the sale of a producible by-product is evident in figure 5. Here we have taken the same data presented in figure 4 and instead of allowing a credit for the sale of the by-product, a reasonable disposal cost has been added. Depending upon the operating factor and the process used, the cost per ton of coal varies between $2.08 and $4.31.

Work is continuing on processes of this type, and apparently one of the large chemical companies is currently planning, in cooperation with a large utility, to build a large-scale test unit utilizing the gas-phase oxidation process. They feel that they have developed sufficient improvements to make the net cost a bit more encouraging than the cost estimates presented here.

Starting at the first of this year, BCR expanded its research efforts directed at finding a reasonable solution to the sulfur problem. This work is being concentrated in two areas: Further research on the removal of pyritic sulfur from coal, and the use of additives to the flue gases which could absorb or otherwise capture the SO_2; solid particulate matter produced would be collected by the existing electrostatic precipitators.

Use of Additives to Fuel May Provide Answer

In light of the earlier mention of the difficulties of substantially reducing the sulfur content of coals by additional cleaning, it might be somewhat surprising that this line of effort is being pursued. However, there are some coals which, while they have a high total sulfur content, do have a reasonable organic sulfur content, and the pyritic material is so associated with the coal that substantial removal can be achieved. One such coal has an organic sulfur content of only 0.55 percent out of the total sulfur content of 3.88 percent (see figure 6). In addition, washability studies show that when crushed to 60 mesh or finer, this pyritic sulfur content can be greatly reduced. Efforts to enable sulfur reduction of coals of this type is not directed at accomplishing it at a preparation plant, but rather, making the removal of pyrite at the power plant inasmuch as the coal must be crushed before combustion. It is believed that economical processes which can be installed between the pulverizer at the power plant and the boiler itself can be developed, and this effort is being pursued.

Initial research with additives, either adding materials such as dolomite or limestone to the coal before

Fig. 4. SO_2 Recovery From Flue Gases

Process Costs—$/ton Coal—With Credits

	@ 90% Factor	@ 50% Factor
Reinluft	1.44	2.65
Alkalized Alumina	1.00	1.64
Catalytic	0.75	2.04

Fig. 5. SO_2 Recovery From Flue Gases

Process Costs—$/ton Coal—Without Credits and with Disposal Costs

	@ 90% Factor	@ 50% Factor
Reinluft	3.10	4.31
Alkalized Alumina	2.08	2.68
Catalytic	2.28	3.57

Fig. 6. Analysis of Pennsylvania Coal

	Sulfur Analysis		
Size	Pyrite	Organic	Total
Raw	3.33	0.55	3.88
	Cleaned at 1.6 Specific Gravity		
2 × 0	1.05	0.55	1.60
¼ × 0	0.95	0.55	1.50
60 M × 0	0.35	0.55	0.90

combustion or injecting them into the gas stream after combustion, appears encouraging. It is at least theoretically possible to effect chemical and physical reactions which will remove the sulfur oxides, but whether this can be done on a reasonably economical basis still must be ascertained.

Air pollution, especially that resulting from the sulfur in bituminous coals, is a hurdle the coal industry must overcome within the next few years if it is going to achieve the growth potential made possible by the expanding electric utility industry. The coal industry is aware of its obligations to protect the health of the general public. In the public interest, it has in the past and will continue in the future to search for ways to improve its product and the means for using that product. We are hopeful that the Utopian objectives for the future relating to "clear air," laudable as these objectives are, will be tempered to fit the realities of the present.

DISCUSSION:

By JAMES R. JONES
Combustion Engineer
Peabody Coal Co.

"NO fuel combustion units larger than 50 million Btu per hour input may be constructed after January 1, 1971, which will or are likely to emit more than 0.5 to 1.0 lb of SO_2 per million Btu per hour input." This means no units larger than 40,000 lb of steam per hour which burn more than 0.25 to 0.5 percent sulfur coal may be built! "During the months of December 1967 and January 1968 no person shall burn or permit the burning of any coal containing more than 1.4 percent sulfur (dry basis) in any fuel-burning installation having a capacity of less than 2000 million Btu per hour."

The above quotes are intended to startle. They are from proposed regulations being urged by health officials and air pollution control agencies. There is, perhaps, no better way to emphasize the necessary research which the preceding article discusses. There is a practical necessity and urgency to the work Bituminous Coal Research, U.S. Bureau of Mines, Monsanto Co., Metropolitan Edison, and others are doing.

National Coal Association began its air pollution control activities many years ago. Following passage of the Clean Air Act of 1963, Mid-West Coal Producers Institute, Inc., for its marketing territory, formulated its own Technical Advisory Committee to supplement the work of NCA. That committee has expanded as specific activities developed, until the organization today is as shown in figure 1.

There is a definite pattern in air pollution work: a strong tendency to copy other ordinances—but in many cases to lower the allowable emission limits a little more than the preceding ordinance. The U.S. Public Health Service and state and local control agencies know more about the ambient air quality than ever before, and in many cases have a better knowledge about emissions from a specific source than that source itself. The Interstate Air Pollution Study at St. Louis has so far released seven of its eight sections. The seven documents measure well over 3½ in. in thickness and just to read the material is a tremendous job.

All Emissions Under Scrutiny. The coal industry is not alone in receiving the brunt of restrictive limitations. Process emissions of all kinds are under scrutiny—odors, gases vapors, particulates, etc. At present, however, primary concern involves two specific areas of

FIG. I MID-WEST COAL PRODUCERS INSTITUTE, INC.

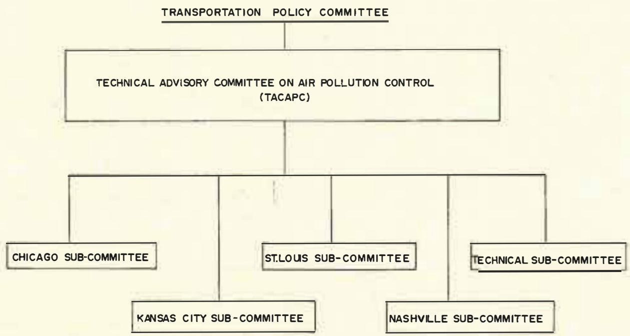
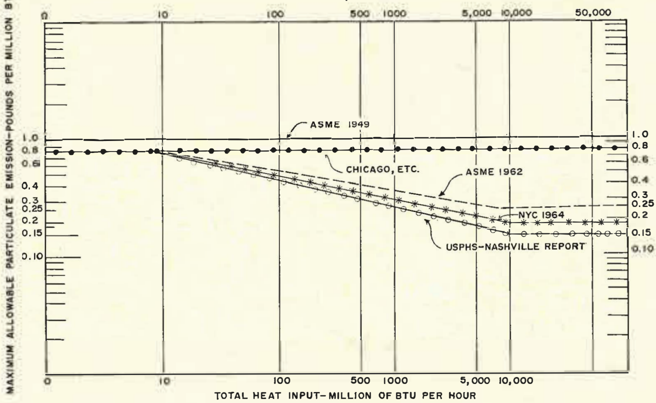


FIG.2 MAXIMUM PERMISSIBLE EMISSION OF PARTICULATE MATTER PER STACK FROM INDIRECT HEATING, FUEL BURNING INSTALLATIONS



investigation: particulate matter and SO_2. We are beginning to be concerned with—and blamed for—the emission of benzo-a-pyrene as mentioned in the previous article. One of these days nitrous oxides will come under closer scrutiny.

Let's look at particulates first. The emission of fly ash is primarily a problem of coal consumers and their burning and collecting equipment. But the coal producer has a stake in this problem through preparation. The size consist of the coal shipped, and the amount of fines therein, have a direct bearing on the results obtained. Also, of equal importance is continuous uniformity of quality and sizing.

A good deal of the technology necessary to prevent the emission of fly ash is known; therefore it becomes a matter of economics. The greater the collection efficiency required, the greater the cost due to larger fans, higher draft loss, more supporting structure, more space required, etc.

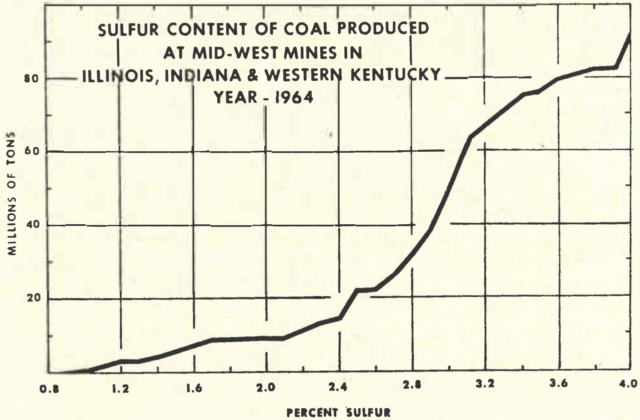
The curves shown in figure 2 are typical of those in existence or being proposed. The old ASME standard (1949) was 0.85 lb of dust per 1000 lb of steam. This is equivalent to 1.0 lb per million Btu input in today's terminology (top curve shown). In 1962 ASME proposed a more restrictive limitation employing the principle of less allowable emission as the size of the steam generating unit increased. This was never adopted; instead, it was referred to an Emission Standards Committee whose report is anticipated in the near future. In the meantime, however, various ordinances have been adopted (as illustrated) and even more stringent figures than these shown are now being proposed.

Better Collection Will Up Costs. What does this mean to the coal industry? On midwestern coals burned in a pulverized fuel unit, this means a collection efficiency of 98 to 99 percent. On industrial sized units fired by a spreader stoker, it means 96 to 97 percent efficiency; for chain or traveling grates or underfeed stokers, 85 to 90 percent. Pulverizers and spreaders will require an electro-static precipitator, which costs 2½ to three times the price of a mechanical collector. To go from 98 to 99 percent collection efficiency will more than double the cost of the collecting device. Coal's competition with oil and gas is particularly intense in the industrial segment of the market. When added collectors are required it places the initial investment even higher for coal equipment than for the gas or oil package unit. Operating costs will also increase with the higher draft loss and greater power requirements. Many plants will be faced with the necessity of discontinuing fly-ash reinjection from the collector in order to meet the new standard, with a resulting decrease in boiler efficiency; however, they might, happily, also find a decrease in maintenance costs due to less slag, erosion of collectors, etc.

Mine Operators Not Immune. The mine operator is not immune to these developing regulations. For example, his coal mine dryer is a source of an "air contaminant" as defined in most laws. He is going to have to learn more about the quantities of dust being emitted. The San Francisco Bay Area process weight emission standards are being quite widely adopted. Every mine operator is urged to study his own situation now before he is forced to take action either by a regulatory agency or as the result of a lawsuit.

So far as gases or vapors are concerned, SO_2 is the principal one with which we are currently concerned. In the first place there is insufficient knowledge about the effects on humans at low levels for prolonged periods of time. The Electric Research Council and the coal industry are supporting research in this area at Hazelton Laboratories, but results will be a long time off as it is a five-year program. Mr. Garvey has quoted the President's Science Advisory Committee report about the lack of evidence of effect on health. For every such statement, those who believe that there is a health

FIG. 3



effect can find similar opinions to support their position. Many statements in the program of educating the public are carefully worded to indicate positive proof of health damage, but qualified by saying there is "increasing evidence," and "tendency to indicate," or some other correlation.

Information relative to the sulfur content of midwestern coals is presented in tables I and II and in figure 3. Referring back to the opening of this discussion, one can readily see the problem that faces the industry with such restrictive regulations. Just multiply the physical problem of making such a presentation of facts before the numerous state and local agencies which are in the process of adopting new ordinances or regulations!

Thus, it is most important to face up to the matter of raw vs. washed coal. Each time we and a customer talk of utilizing uncleaned coal, we place ourselves at the opposite end of the table from control agencies.

Situation is Urgent.

To summarize:

1. There is a matter of urgency being placed on this subject of air pollution control. We are in favor of cleaning up our air. Everyone can point to examples in his own community where something should be done. Our aim, however, is to have control that does not precede the technical knowledge for compliance. We are, in effect, "buying time." But we must use that time productively to find answers to the many unsolved problems. Removal of sulfur from the coal and SO_2 from the flue gases are just two of these.
2. We have gone far beyond the days of the smoke inspector who concerned himself only with the color of the effluent from the stack and the flyash which fell in the neighborhood creating a nuisance. Perhaps much progress is being made in finding solutions to the problem, but are the city councils, health officials, citizens' committees, etc., equally convinced and willing to wait?
3. What can an individual with a personal stake in the future of the coal industry do?
   —Find out how much dust you are emitting from your preparation plant. Does it meet modern-day standards? If not, correct the situation before public indignation forces you into something far more stringent.
   —Maintain your coal preparation and quality at the highest standards possible. Size consist and uniformity are of particular importance. Poor coal and an active air pollution control program mean loss of a customer.
   —Be a "one-man" public relations emissary for the coal industry. Tell your neighbors, friends, and the general public how important coal is to their every-day existence. Also tell them about the all-out cooperative efforts of the coal industry to reduce air pollution.

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TABLE I. SULFUR CONTENT* OF COAL PRODUCED AT MID-WEST MINES IN ILLINOIS, INDIANA & WESTERN KENTUCKY

YEAR—1964

% SULPHUR	TONS OF COAL	CUMULATIVE TONNAGE	CUMULATIVE %
1.0	486,000	486,000	0.5
1.2	2,876,000	3,362,000	3.7
1.3	404,000	3,766,000	4.1
1.4	928,000	4,694,000	5.1
1.5	1,665,000	6,359,000	6.9
1.7	2,085,000	8,444,000	9.2
2.1	582,000	9,026,000	9.8
2.3	4,417,000	13,443,000	14.7
2.4	1,385,000	14,828,000	16.2
2.5	7,751,000	22,579,000	24.6
2.6	312,000	22,891,000	24.9
2.7	3,661,000	26,552,000	28.9
2.8	5,878,000	32,430,000	35.4
2.9	6,131,000	38,561,000	42.1
3.0	12,238,000	50,799,000	55.3
3.1	11,751,000	62,550,000	68.1
3.2	4,401,000	66,951,000	73.0
3.3	4,143,000	71,094,000	77.5
3.4	4,685,000	75,779,000	82.6
3.5	797,000	76,576,000	83.4
3.6	2,885,000	79,461,000	86.6
3.8	3,086,000	82,547,000	89.9
3.9	310,000	82,857,000	90.3
4.0	8,968,000	91,825,000	100.0

* As Received

BY RANGE OF SULFUR % (Tons of Coal)

1.0–1.5	1.6–2.0	2.1–2.5	2.6–3.0	3.1–3.5	3.6–4.0
6,359,000	2,085,000	14,135,000	28,220,000	25,777,000	15,249,000

Source: Mid-West Coal Producers Institute, Inc.

TABLE II. TYPICAL FORMS OF SULFUR IN ILLINOIS, INDIANA, AND WESTERN KENTUCKY COALS (CLEANED COALS)

Seam	District	Pyritic	Sulfate	Organic	Total Sulfur
		As Received Basis			
ILLINOIS					
#2	Northern Illinois	.76	.18	1.14	2.08
#5	Southern Illinois	1.41	.07	1.12	2.60
#5	Fulton County	1.17	.15	1.72	3.04
#6	Fulton County	.93	.13	1.69	2.75
#6	Central Illinois	1.59	.09	1.98	3.66
#6	Belleville	1.23	.06	2.03	3.32
#6	Southern Illinois	.77	.01	1.77	2.54
#6	Southern—Low Sulfur	.45	.04	0.61	1.10
#7	Northern Illinois	1.28	.17	2.19	3.64
INDIANA					
#3	Brazil Clinton	1.78	.02	1.99	3.79
#5	Terre Haute Area	1.02	.07	1.72	2.81
#6	Southern Indiana	1.40	.12	1.17	2.69
#7	Terre Haute Area	.41	.03	.52	.96
Brazil Block (Raw Coal)	Terre Haute Area	.58	.03	.67	1.28
WESTERN KENTUCKY					
#6	Madisonville Area	1.87	.07	0.79	2.73
#9	Madisonville Area	1.27	.08	1.76	3.11
#11	Madisonville Area	1.18	.07	1.77	3.02
#12	Madisonville Area	1.29	.08	1.62	2.99
#14	Madisonville Area	1.22	.08	1.10	2.40